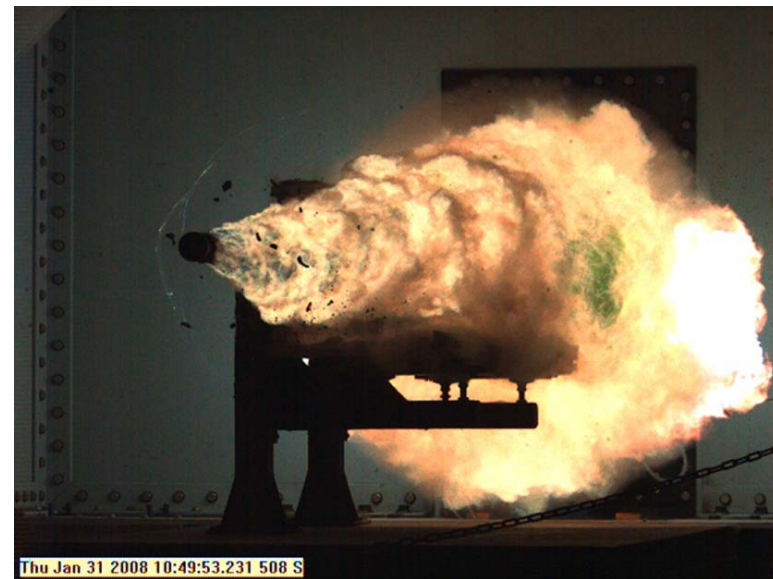




# *An Evaluation of Rail Gun Technology for Launch Assist of Air Breathing Rockets*



US Navy released photo of a 10 MJ, 2500 m/sec rail gun firing (2008).

If we need to launch a hypersonic plane from the ground at a speed over Mach 1 (340 m/sec), should we try to increase the speed of high speed rail motors or should we consider slowing down rail gun capabilities, modifying this to handle larger masses? Before this study NASA had only considered the first option.



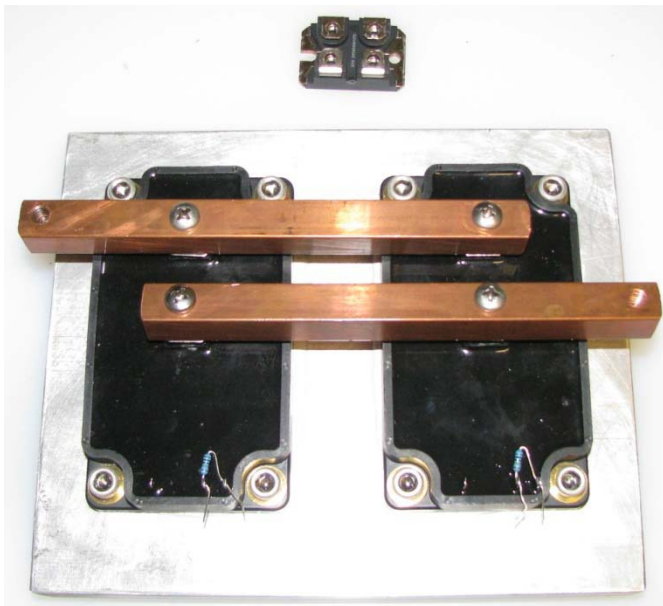
The Chinese CRH380A reached 259 mph (116 m/sec) on Sept. 28, 2010.



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Two technology advances now allow rail guns to operate at lower speeds with higher masses. Replacing the 0.1 Farad capacitor banks used in guns with 3000 Farad capacitors extends the time scales from milliseconds to seconds. A 66 kilo-Joule pack is shown to the right composed of six 3000 Farad capacitors.

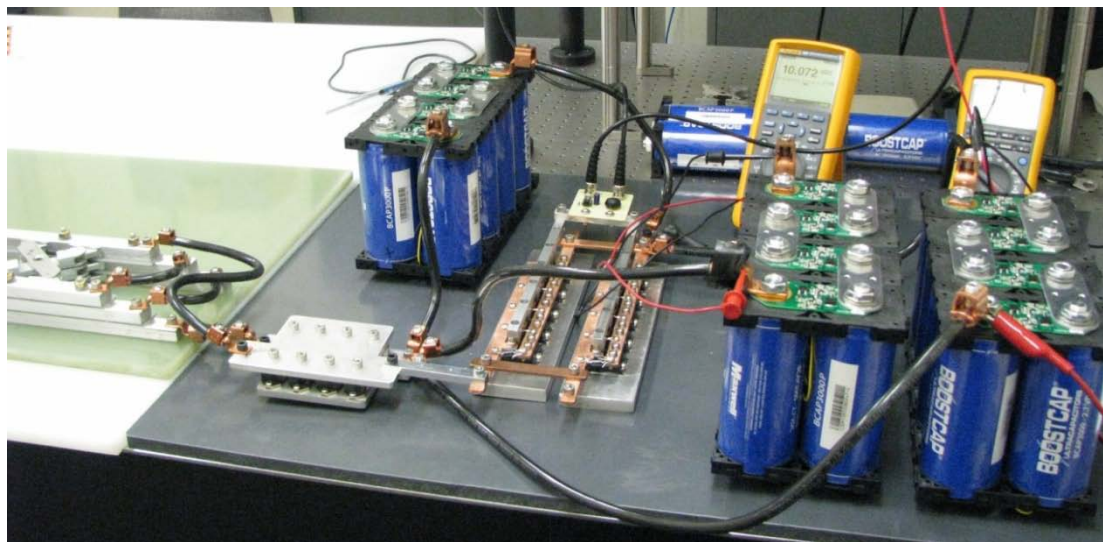
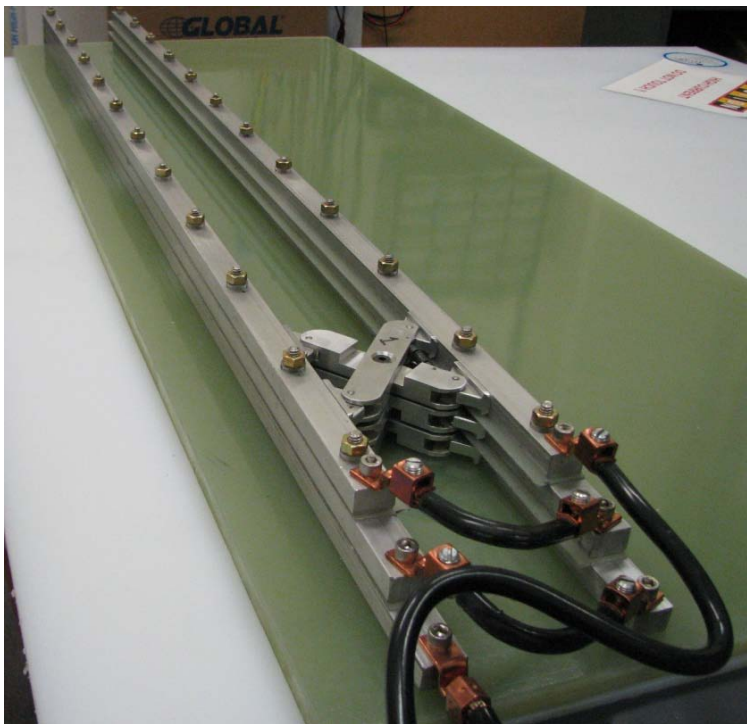


Theory predicts that the best velocity for a rail type track is given the resistance divided by the inductance gradient; meaning that low resistance is critical to operating a rail gun at lower speeds. So MOSFETs were studied as switches and, fortuitously, this technology advanced steadily during the project. To the left is a March 2010 MOSFET bank (\$600) with 4.5 milliOhms on-resistance and a June 2010 MOSFET(\$40) with 1.9 milliOhms on-resistance (in Sept. 2010 0.8 milliOhm (\$7) devices were available).





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Above is a 2.3 milliOhm Power Supply with 1125 Farads of capacitance operating at 15-20 volts. 10 parallel MOSFETs are used to switch up to 5000 Amps. To the left is a three layer, high inductance, recirculating, rail/sled. This system can exert more than 50 Newtons of force on the 320 gram sled yielding, minus friction, 14 Gs of acceleration.

The result of the study is that recent technology advances coupled with novel rail gun designs should allow high-mass sled systems to be constructed that operate efficiently at low speed, yet can be built in stages to achieve very high final launch speeds. With new MOSFETs appearing and active research in super capacitors ongoing, this is a competitive launch assist technology that should be further explored.